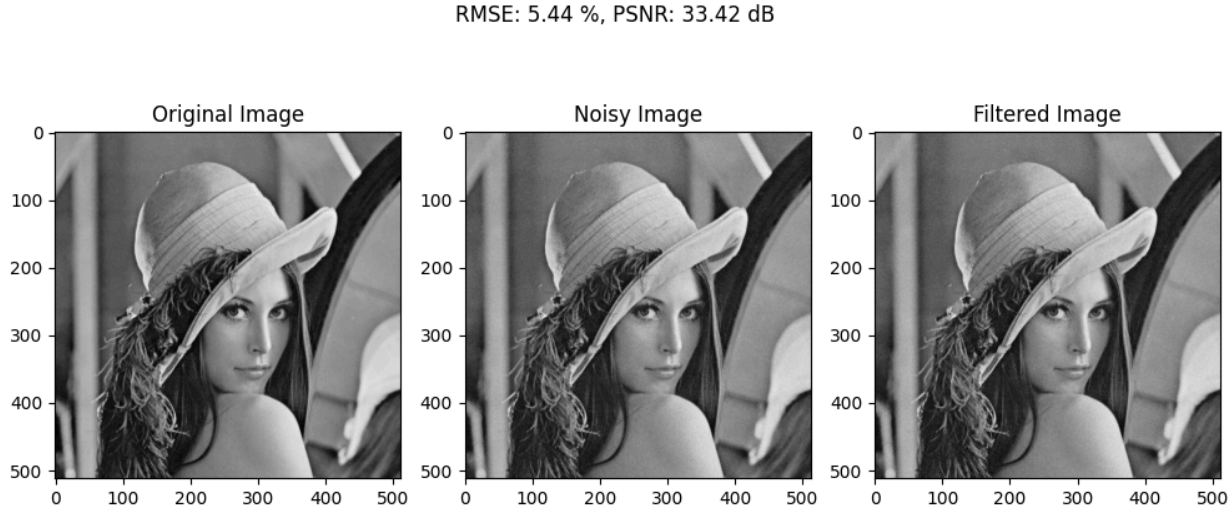
Project Report: Exposure Value Mean Filtering

This project focused on developing a rank order EV (Expected Value) filter aimed at reducing noise in grayscale images while preserving essential image details. Using a mean-based approach, the filter calculates the average of neighboring pixel values within a specified window, effectively smoothing random noise across the image. The filtering process is guided by the standard deviation of the noisy image, which serves as the EV parameter. This parameter allows the filter to adjust dynamically: images with higher noise levels receive a stronger noise-suppressing effect, while lower-noise images are processed more subtly, balancing noise reduction with detail retention. To handle image borders consistently, the function employs mirrored padding, where edges are reflected to create a seamless transition. This padding method prevents boundary distortions commonly encountered in filtering, enabling the filter to operate uniformly across all pixels without introducing artifacts.

A key feature of the filter is its adaptable window size, which allows it to respond more effectively to different noise conditions. By adjusting the window parameter, users can select a smaller window for applications requiring high detail preservation or a larger window for more aggressive noise reduction in high-noise environments. Testing revealed that a standard 3x3 window size provides an optimal balance for most images, offering noise reduction while preserving details. Larger windows, such as 5x5, offer greater noise smoothing at the expense of some finer details, which can be beneficial for particularly noisy images. This adaptability in window sizing, combined with mirrored padding, results in a filter design that produces improved output quality across varying noise levels. This EV mean filtering approach thus presents an effective solution for noise reduction in image processing, delivering a balance of clarity and adaptability while also providing a foundation for future enhancements, such as adaptive window sizes based on local noise characteristics within the image.



When running the code this is the output in the terminal. We begin by choosing the image you want to process, in this case lena_color - > but in the main.py the image is then converted into grayscale. The window size is 3 and the rmse ~ 5.43 % and psnr ~ 33.42 dB. The rmse value is considered great as its considered to closely resemble the original. As for the psnr, there is some distortion still present in the filtered image, but above 30 dB is considered okay.

```
Available TIFF files from Testing directory:
1: Girl.tif
2: Airplane-F16.tif
3: Bridge.tif
4: Barbara.tif
5: Lena_Y.tif
6: Lake_Y.tif
7: SailBoat.tif
8: Boat.tif
9: Lena_Y-Scratches.tif
10: BigBen.tif
11: Lena_Color.tif
12: LowContrast-a.tif
13: Temple_Y.tif
14: LowContrast-b.tif
15: Pepper_Y.tif
16: Airplane-F16_Y.tif
17: LowContrast-c.tif
18: Pepper.tif
Choose the first file (1-18): 11
Processing files: ./Test_Images/Lena_Color.tif

Input the noise fraction for image: 0.1
Input the window size: 3
+----------------------+----------------------+
| Original v. Filtered |                      |
+----------------------+----------------------+
| RMSE                 | 5.436677604529046 %  |
+----------------------+----------------------+
| PSNR                 | 33.42413200741032 dB |
+----------------------+----------------------+
```

When comparing the rmse/psnr from project 3 DRID filter it can be seen in the table below.

RMSE ~ 32.73655 %	PSNR ~ 17.83014 dB	DRID
RMSE ~ 43.4270 %	PSNR ~ 15.37559 dB	DRID
RMSE ~ 29.8108 %	PSNR ~ 18.643324 dB	DRID
RMSE ~ 5.436677 %	PSNR ~ 33.424132 dB	EV

The development and application of the rank order EV (Expected Value) filter demonstrated a highly effective approach to noise reduction in grayscale images. The EV filter, using a mean-based approach and dynamically adjusting based on the standard deviation of noise, was able to provide superior image quality when compared to other methods, such as the DRID filter evaluated in Project 3. By calculating an average of neighboring pixel values and employing mirrored padding to address border artifacts, the EV filter achieved a strong balance between noise suppression and detail preservation. The filter's adaptability in window size further allowed for customization based on noise intensity, with a 3x3 window size delivering the

optimal trade-off between noise reduction and image clarity. Larger windows were beneficial in particularly noisy images, albeit with minor sacrifices in finer detail.

Analysis further supports the EV filter's performance, with an RMSE of approximately 5.43% and a PSNR of 33.42 dB, indicating a close resemblance to the original image and minimal distortion. In comparison to DRID filter outputs, which had significantly higher RMSE values (up to 43.43%) and lower PSNR values (as low as 15.38 dB), the EV filter demonstrated marked improvements. These metrics affirm the EV filter is better in image quality, with lower RMSE and higher PSNR correlating to better fidelity to the original image.